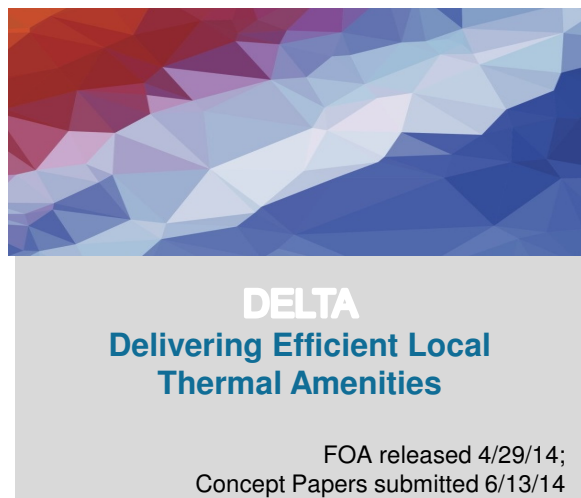


Enabling Energy Efficient Building Management Through Reduced CAPEX

ARPA-E Mini-workshop

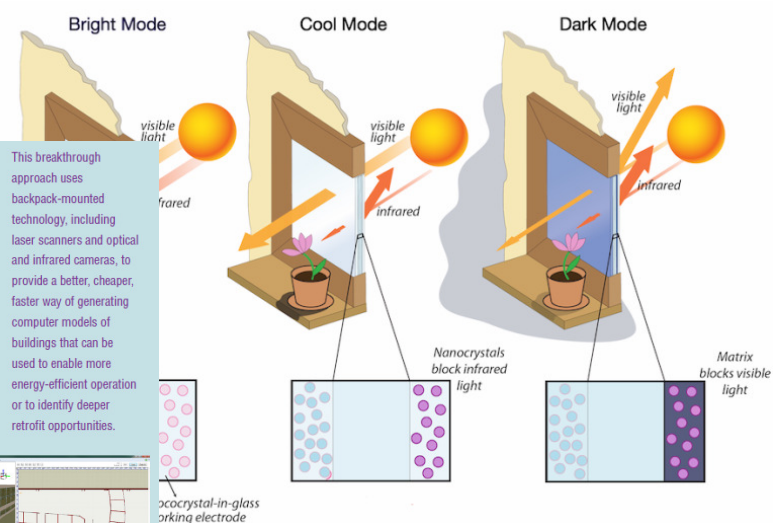
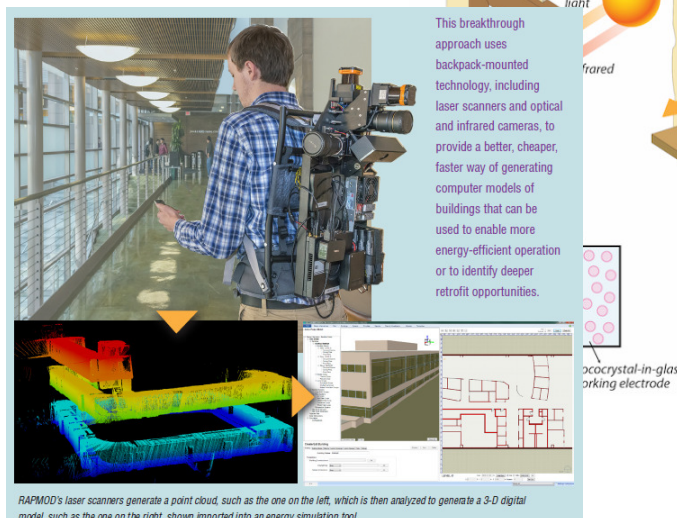
October 23, 2014

ARPA-E – Buildings Technology



Building Energy Efficiency Through
Innovative Thermodevices

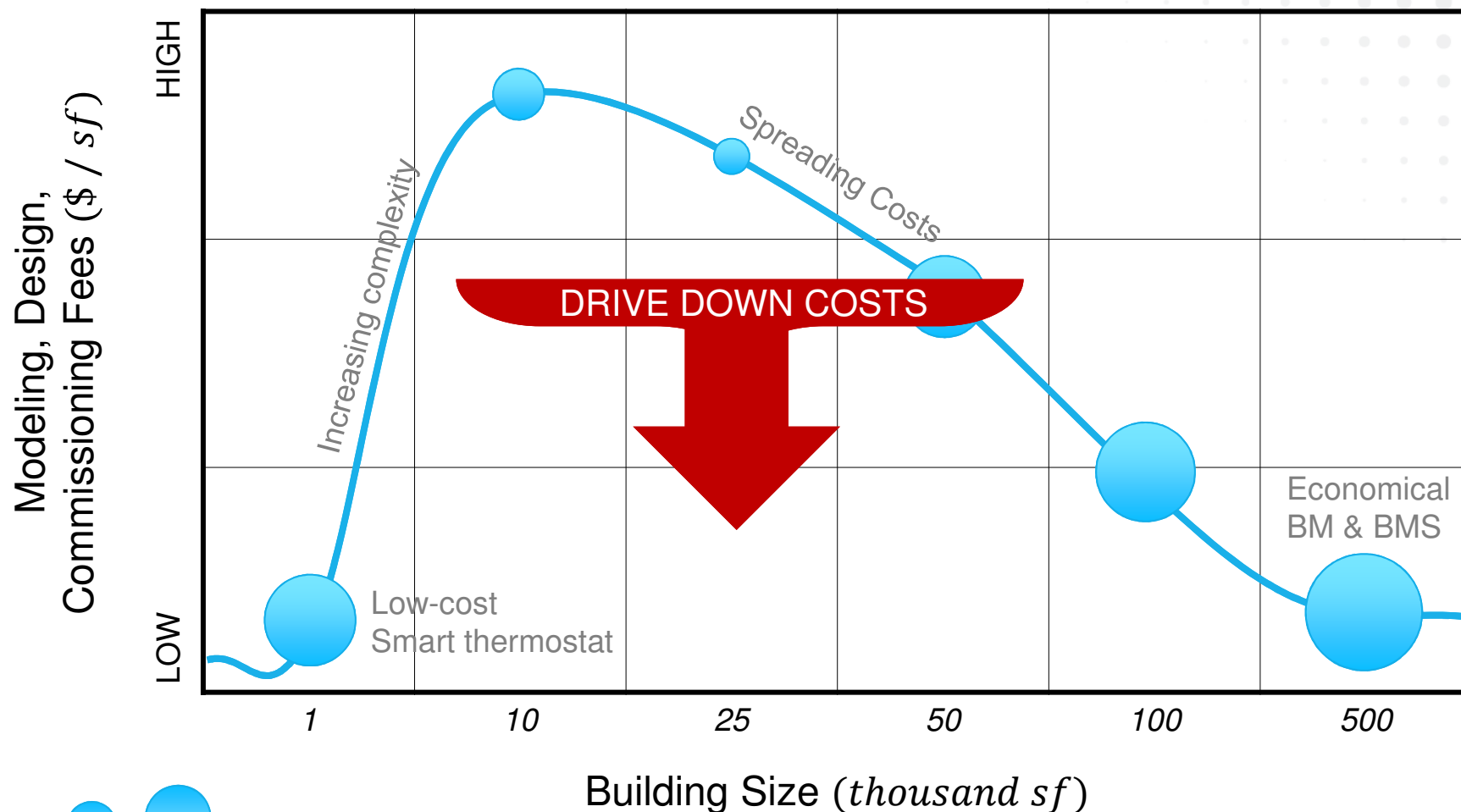
BEETIT



Hypothesis

- ▶ The latest breakthroughs in building controls have demonstrated significant **efficiency improvements**.
 - Experiments using model-predictive control have yielded energy reductions of 10 – 12% [[Oldewurtel](#)] and 60% [[Bengea](#)] over a baseline business as usual.
- ▶ Advanced energy saving building controls are **costly** to design, install, and tune for each **one-off** building.
 - Green premium ranges between 0% – 6.5% – 9%. [USGBC: [1,2,3](#)]
 - Commissioning costs range from \$0.30 to \$2.50/ft² [[Nicolow](#)]
- ▶ **Hindered adoption** of these systems prevents energy savings nation-wide of greater than **1.0quad per year**.
 - Total US residential and commercial HVAC used ~9 *quad* in 2010

The Whitespace for Energy Saving Controls



Energy Intensity

[EIA Building Energy Data Book](#), [RSMeans Online](#), [LBL Report](#)

Outline

- ▶ Workshop objectives
- ▶ US building energy consumption
- ▶ Current trends in building energy efficiency
- ▶ The challenge of mid-sized buildings
- ▶ Enabling technologies
- ▶ Workshop objectives reminder
- ▶ Workshop agenda

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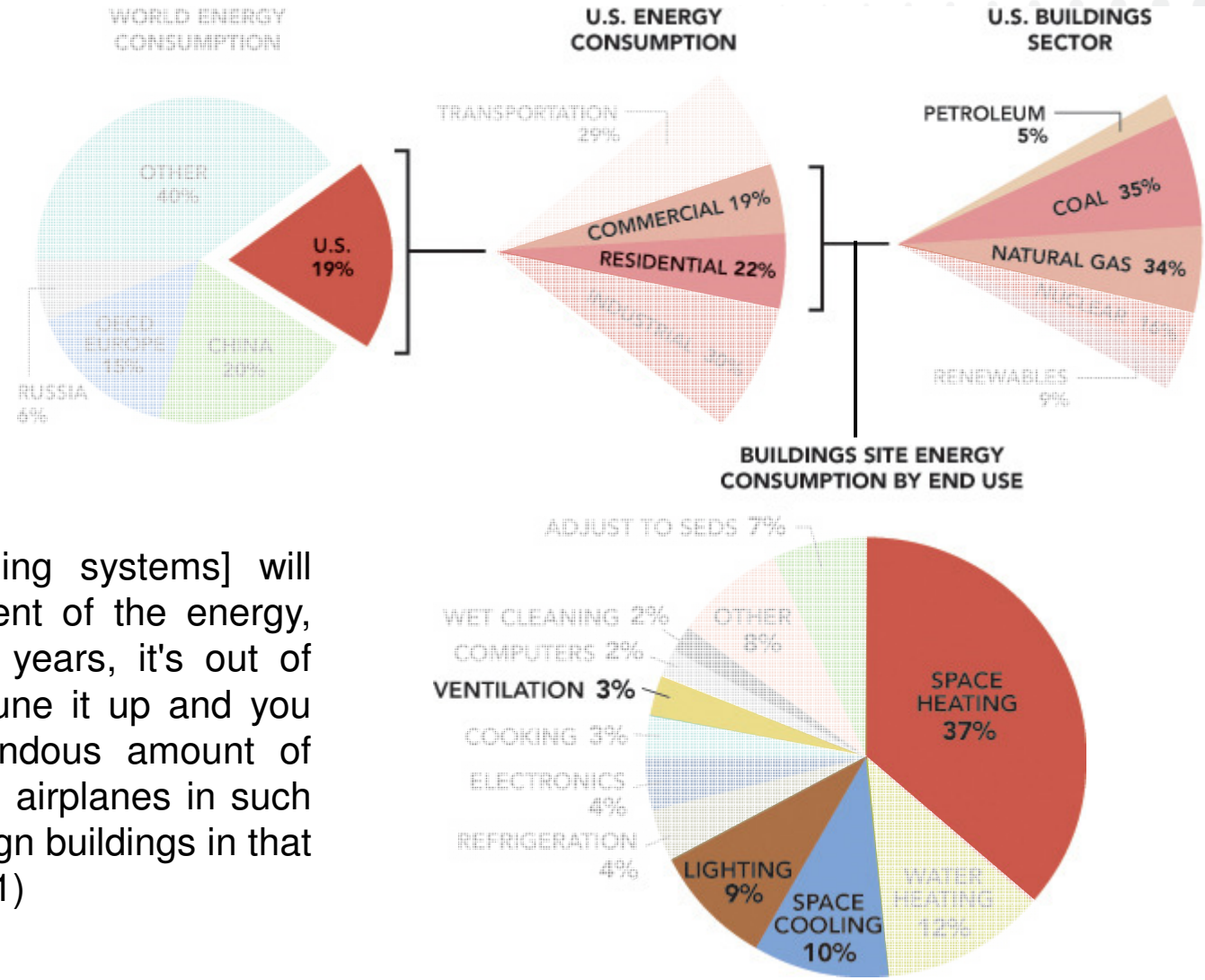
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US Energy Consumption

HIGH BUILDING ENERGY USAGE

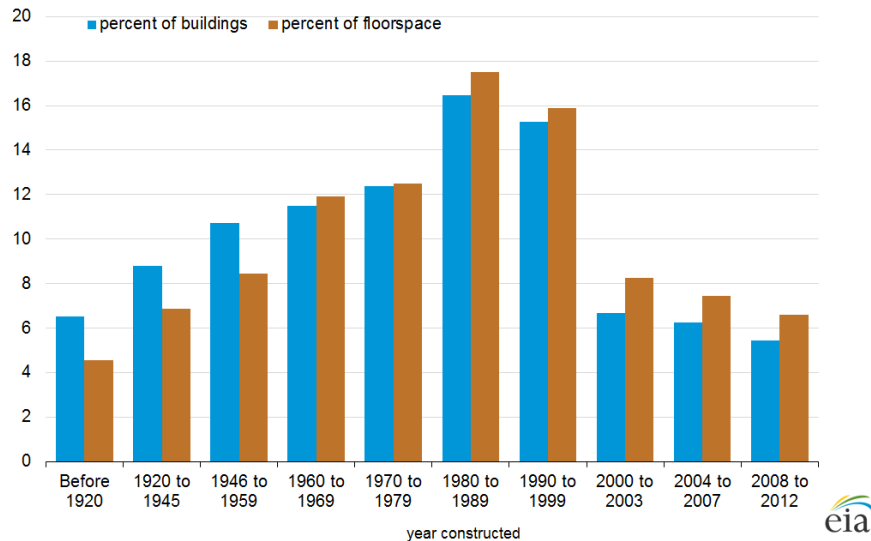
“[New smart building systems] will save 10-plus percent of the energy, and then after 20 years, it's out of tune, you can re-tune it up and you will save a tremendous amount of energy...We design airplanes in such a way, we can design buildings in that way too.” (Chu 2011)



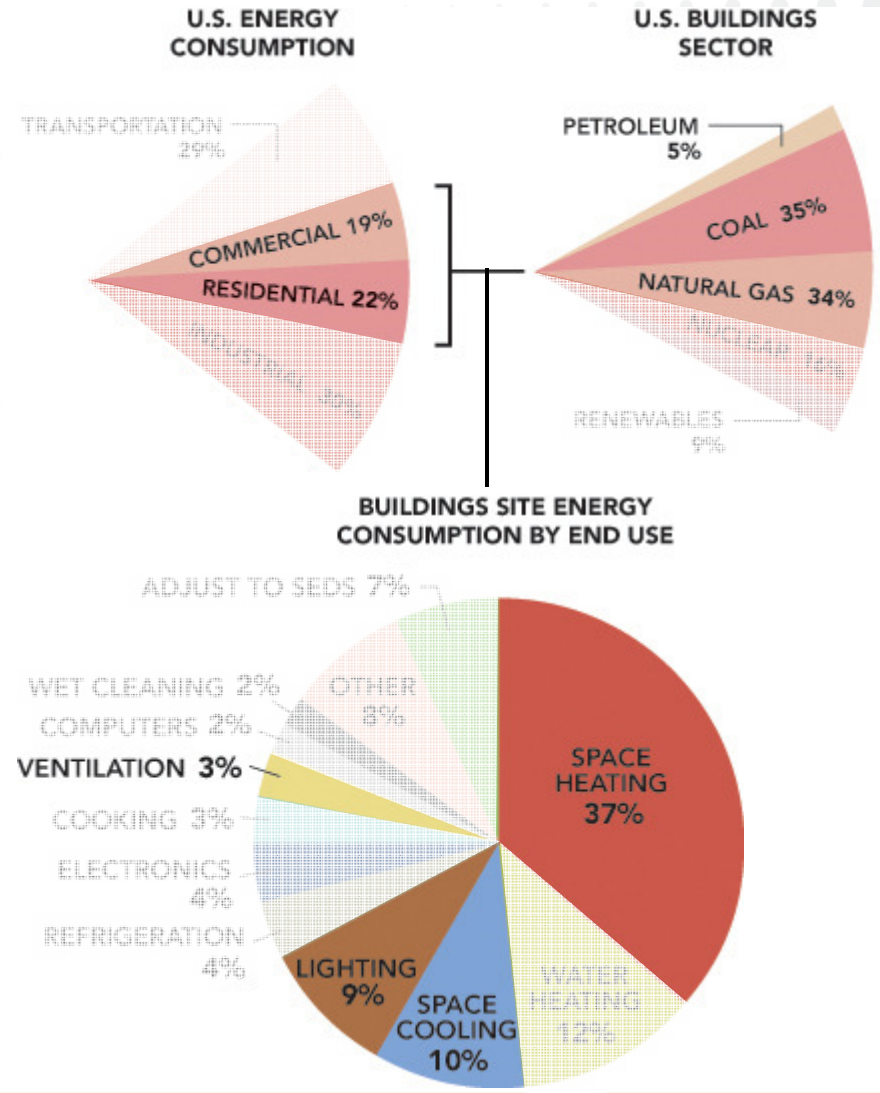
US Energy Consumption

IN-EFFICIENT LEGACY BUILDING STOCK

Figure 6. About half of all commercial buildings were constructed before 1980



LESS THAN 2% INDUSTRY R&D SPENDING



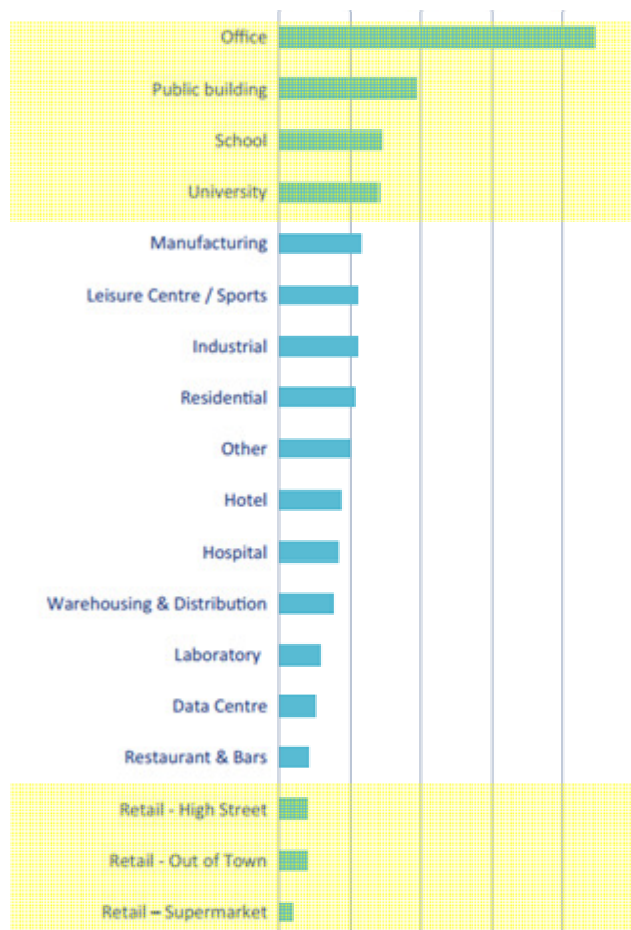
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Who is doing What?

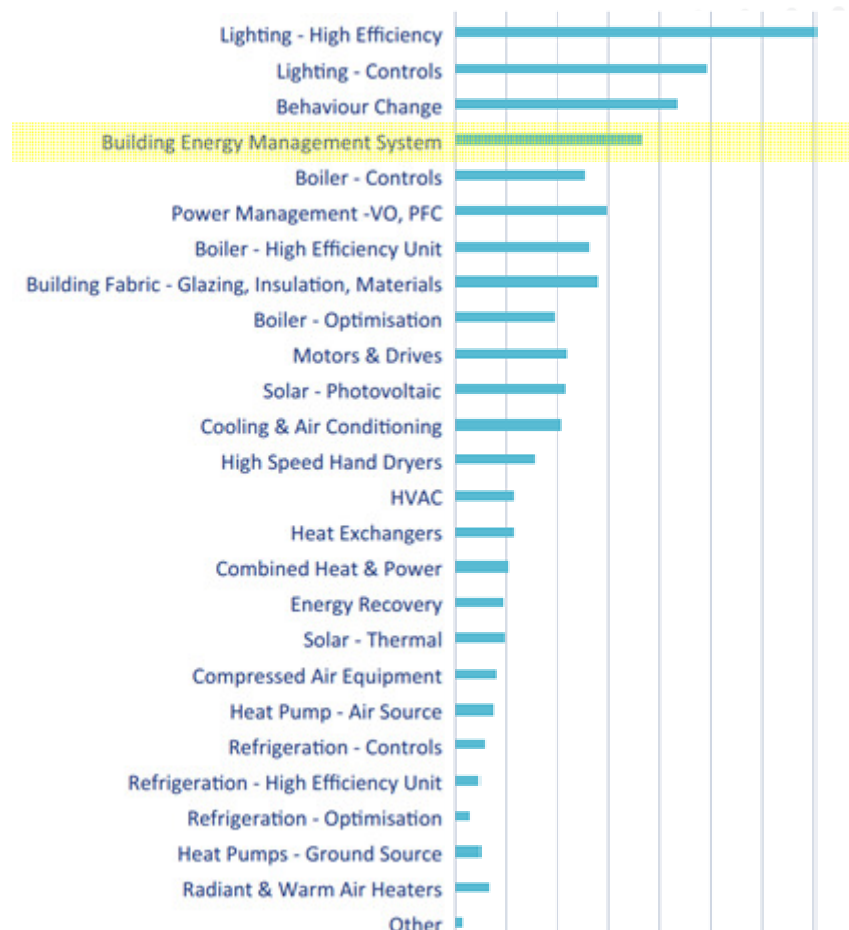
► Who: building type

% of respondents to EEVS / Bloomberg *Energy Efficiency Trends* surveys.



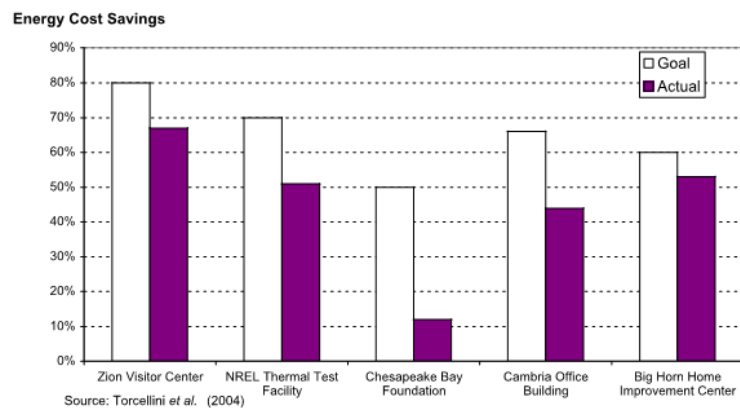
► What: type of EE projects

% of respondents to EEVS / Bloomberg *Energy Efficiency Trends* surveys.



Retro-commissioning

COMPARE PERFORMANCE



lbl.gov

TEST ENVELOPE



www.horizon-engineering.com

PREVENT/ID DEGRADATION



www.myhvacperformance.com

TUNE BMS



www.glumac.com

Building Analytics & Control

Microsoft's Smart Campus



"Our smart buildings work serves up data for me in easily consumable formats so now I get to spend 95% of my time doing engineering, which is great."

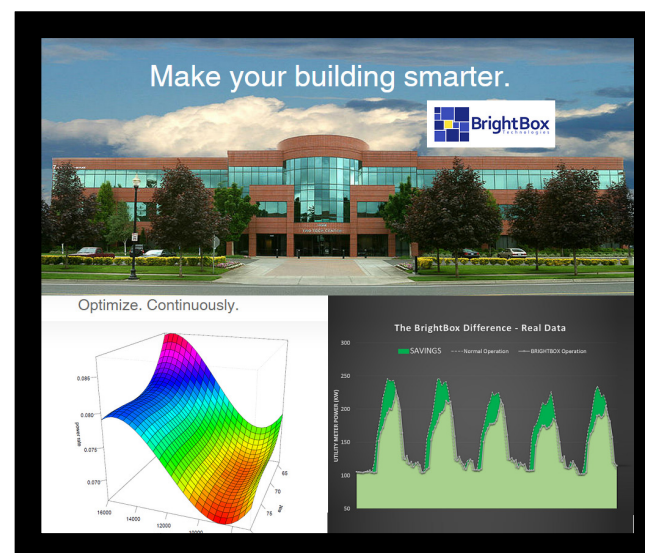
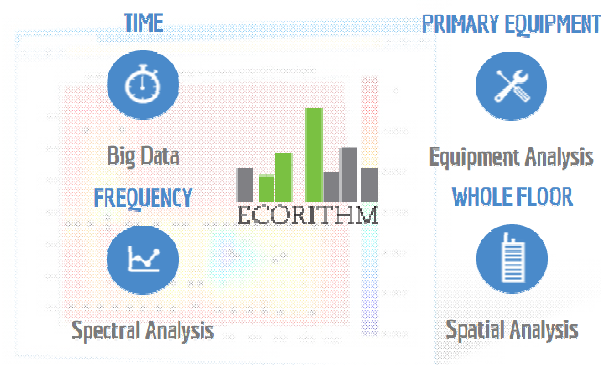
- Jonathan Grove, Engineer
Microsoft

125
buildings with...
2,000,000
data points

500,000,000
data transactions
every 24 hours



Communicated through an array of different
**Protocols, Hardware,
and Interfaces**



Smart Thermostats

Cost of Selected Thermostats



\$249



\$249

\$299



\$244



Smart Thermostats

Estimated Payback Period



1.4 yrs



1.4 yrs

+ Connection point with
the rest of the smart home

1.7 yrs



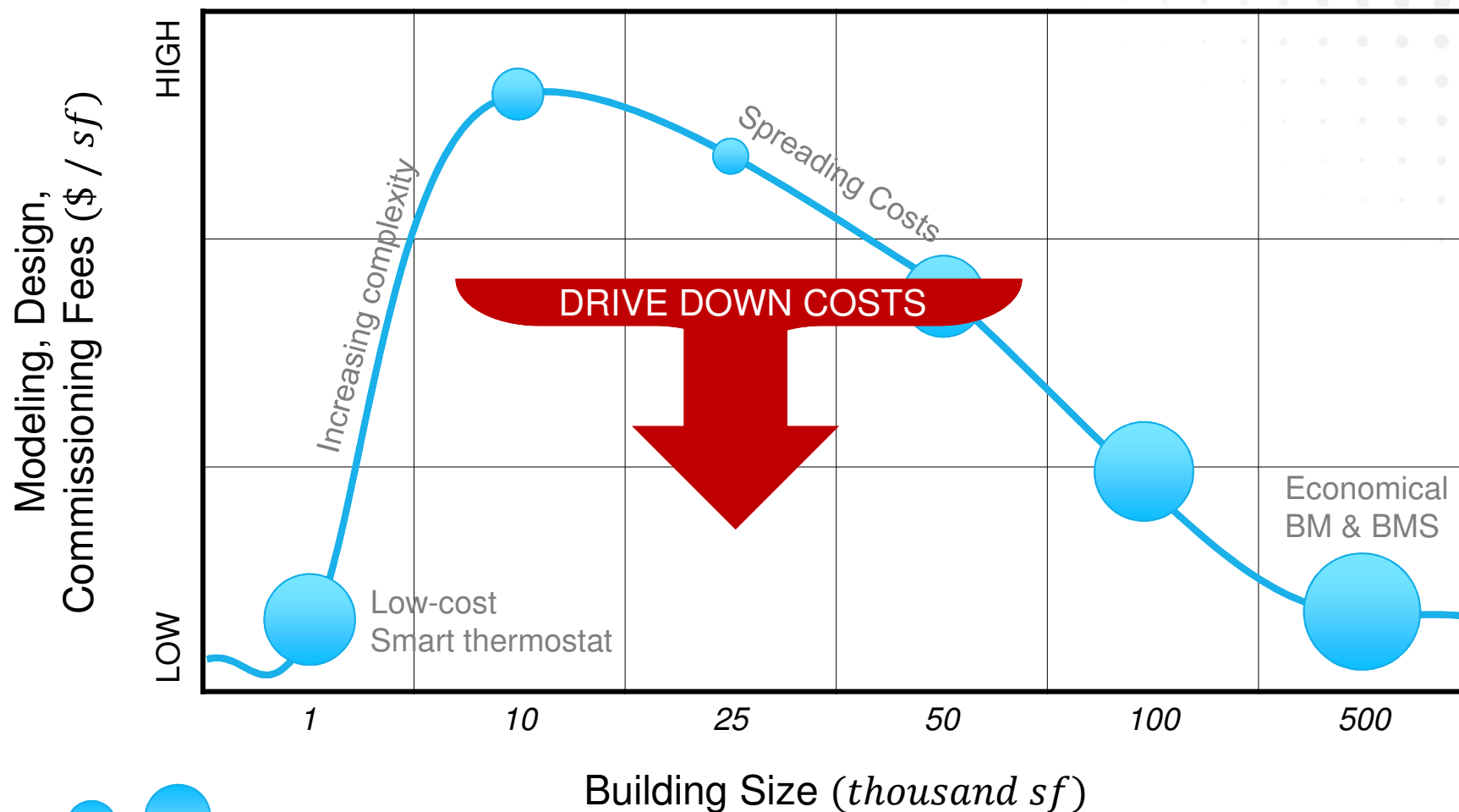
1.4 yrs



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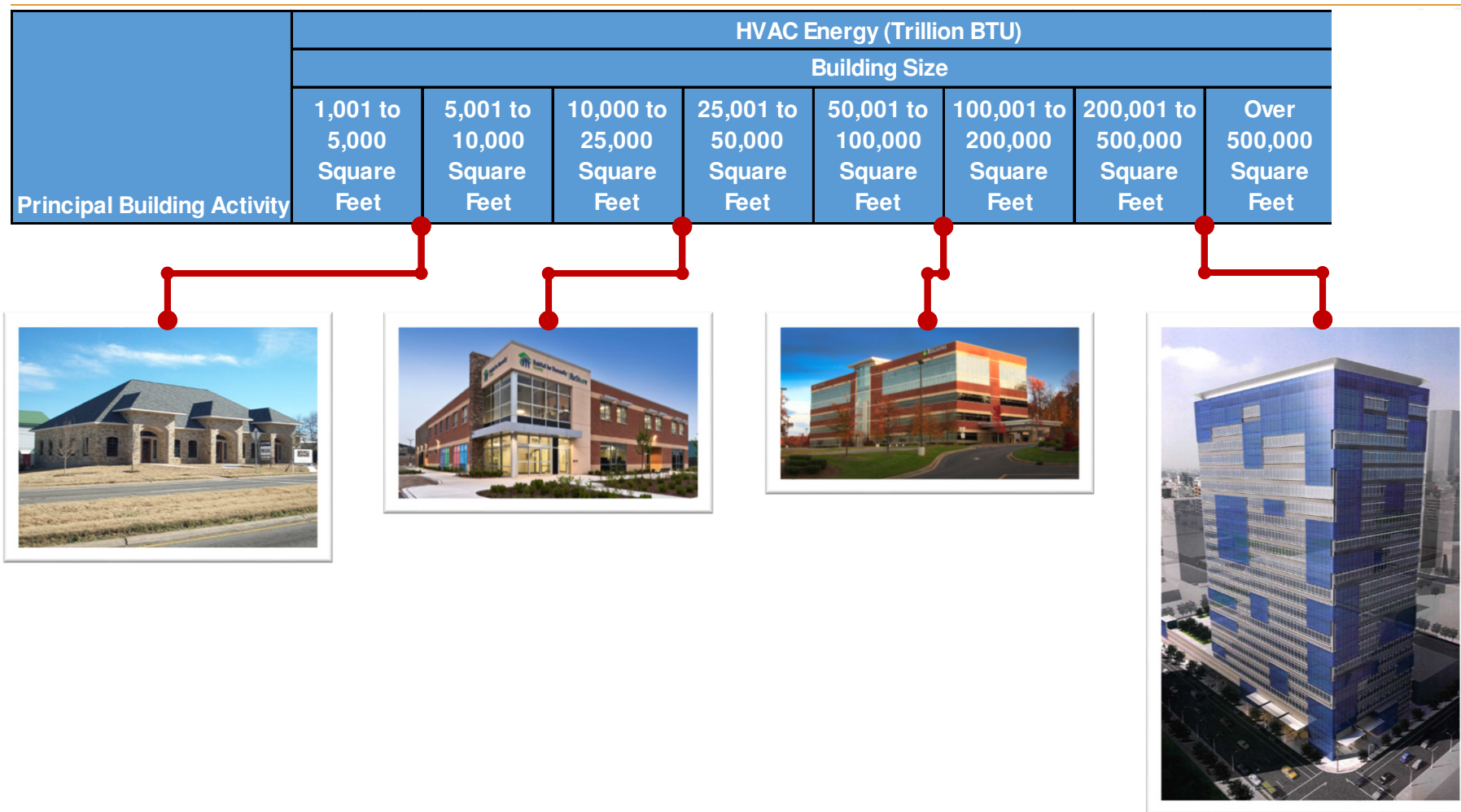
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HVAC Energy Usage



HVAC Energy Usage

Principal Building Activity	HVAC Energy (Trillion BTU)							
	Building Size							
	1,001 to 5,000 Square Feet	5,001 to 10,000 Square Feet	10,000 to 25,000 Square Feet	25,001 to 50,000 Square Feet	50,001 to 100,000 Square Feet	100,001 to 200,000 Square Feet	200,001 to 500,000 Square Feet	Over 500,000 Square Feet
Education	27	23	59	100	163	104	53	
Office	71	45	95	76	60	77	32	47
Public Assembly	27	38	91	25	39	68		
Enclosed and Strip Malls		19	55	33	59	52		44
Warehouse and Storage	20	19	51	23	36	27	32	
Service	60	34	53	29				
Religious Worship								
Retail (Other Than Mall)						21		
Lodging						31	42	
Food Service								
Outpatient								
Food Sales								
Vacant								
Inpatient							51	65
Public Order and Safety	12							
Other								

*1.00 quad (commercial)
+0.25 quad (multi-family res.)*

~1.25 quad Mid-sized HVAC

EIA Building Energy Databook

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Federal Research Dollars...

A low cost, wireless “peel and stick” sensor

U.S. DEPARTMENT OF
ENERGY Energy Efficiency & Renewable Energy

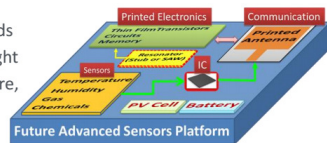
Opportunity: Cheap and wireless sensors will enable enhanced building controls; requirement for future transaction platform

Problem: Communicating sensors are too expensive

Solution: Low cost, wireless sensors that are fully printable “peel and stick” and cost \$1-\$10/node vs. \$150-\$300/node

FY13 goals (metrics): Prototype multi-sensor platform

- Comprised of new high performance materials using a unique low temperature thin film integration platform
- Performance specifications:
 - Transmission rate: every 80 seconds
 - Power harvesting from ambient light
 - Parameters measured: Temperature, humidity, light intensity
 - Range: 50 feet (tested), expected range (2K-3K feet)
 - RF frequency: 315 MHz



13 | Building Technologies Office

ee.energy.gov

Models, Tools, and Information Resources

Data-driven Decision Making

Opportunity

Communicate the value of energy efficiency to encourage adoption of technologies (lower the risk).

Strategy

- Inform users about their energy use and ways to reduce it.
- Enable comparison of energy efficiency opportunities.
- Educate building science professionals.

Recent Accomplishments & Impacts



BUILDING AMERICA SOLUTION CENTER

- THOUSANDS** of building datasets
- OVER 1,250,000** building energy model and software users
- 10+** tools
- HUNDREDS** of innovations proven by experts
- OVER 500** case studies and reports

U.S. DEPARTMENT OF
ENERGY Energy Efficiency & Renewable Energy

13

Author
Assista
ECE Dr
Carneg



Building Energy Management Open-Source Software Development (BEMOSS)

FOA822 Project Meeting (DE-EE0006352)

Prof. Saifur Rahman

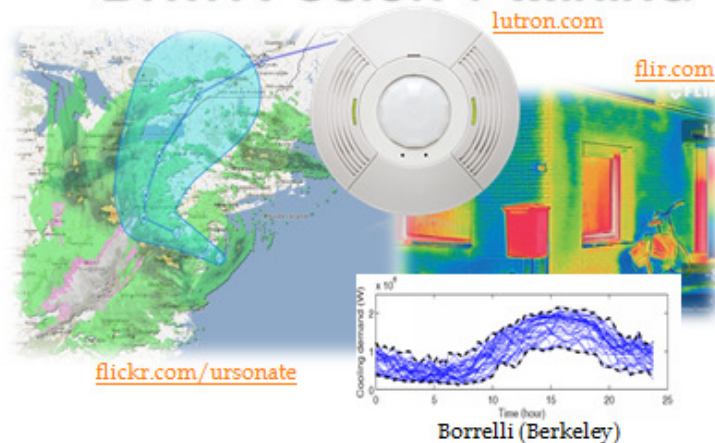
Virginia Tech - Advanced Research Institute



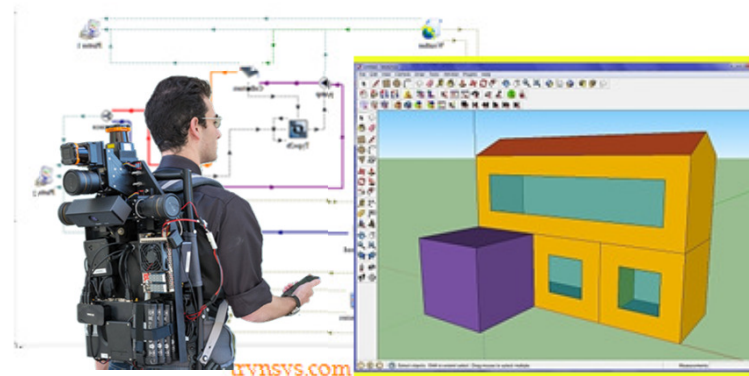
What do we do with all the sensors & platforms?

You All!

DATA FUSION + MINING



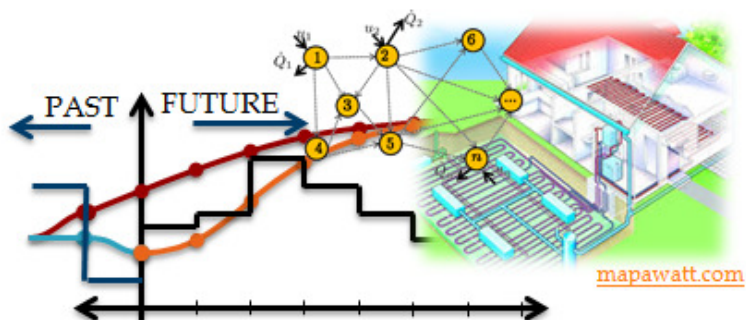
MODEL SYNTHESIS



UI / UX



ADVANCED CONTROLS AND HVAC ARCHITECTURES



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Agenda

8:45AM	30m	9:15AM	Registration & Breakfast	-
9:15AM	15m	9:30AM	Welcome & Introduction to ARPA-E	Eric Rohlifing (ARPA-E)
9:30AM	30m	10:00AM	Introduction to workshop	Mike Kane (ARPA-E)
10:00AM	45m	10:45AM	Lightning Introductions	All
10:45AM	15m	11:00AM	Coffee break	-
11:00AM	15m	11:15AM	Novel modeling and controls of buildings	Igor Mezic (UCSB)
11:15AM	15m	11:30AM	Breakthroughs in sensing and data systems	Sidhant Gupta (Microsoft)
11:30AM	15m	11:45AM	Implementation considerations presentation	Jon Judkoff (NREL)
11:45AM	45m	12:30PM	Breakout #1: Defining the opportunity	SEE GROUPS
12:30PM	45m	1:15PM	Lunch	-
1:15PM	15m	1:30PM	Breakout #1: Readout	Note takers
1:30PM	60m	2:30PM	Breakout #2: The straw-man	SEE GROUPS
2:30PM	15m	2:45PM	Recess	-
2:45PM	60m	3:45PM	Breakout #3: Future R&D	SEE GROUPS
3:45PM	30m	4:15PM	Readouts from breakouts	Note takers
4:15PM	30m	4:45PM	Open floor and wrap-up	Mike Kane (ARPA-E)